CIVIL DEFENSE

EMERGENCY HANDLING of RADIOACTIVE & METALLIC FIRES

A HANDBOOK FOR FIRE DEPARTMENTS

CIVIL DEFENSE DIVISION

DEPARTMENT OF MILITARY AFFAIRS

Table of Contents

EMERGENCY HANDLING OF RADIOACTIVE AND METALLIC FIRES
A HANDBOOK FOR FIRE DEPARTMENTS

Introduction:

The following handbook has been written to assist you, the fireman, in properly handling a fire involving radioactive material and/or pyrophoric metals. Part I briefly describes the types of incidents that may occur, what to do until qualified radiation physicists arrive at the scene and whom to notify regarding the radiological incident. Part II provides essential information for personnel that must handle a radiation accident victim. Part III gives basic information regarding the pyrophoric metals, their chemical and physical properties, and fire extinguishing recommendations. Appendices A through G provide information pertinent to warning labels, report forms, handling radioactive contamination, equipment to maintain, general information on radiation quantities and units and care of radiation survey instruments. A Glossary of Terms is included at the end of this handbook.

It should be noted that the procedures and fire fighting recommendations are not necessarily specific for all types of situations and may vary according to the kind of fire, its location and the presence of other combustible materials. Considerable research is still needed in the field of metal pyrophoricity. The fire extinguishing chemicals suggested represent some of the best knowledge on this subject to date.

Pages 11A and 11B contain a quick reference table listing suggested fire extinguishing agents.

NOTICE REGARDING BRAND NAMES

The Montana Department of Health and Environmental Sciences has used the brand name "MET-L-X" in this handbook for the purpose of describing a chemical compound that functions as a broad spectrum extinguishing substance for metallic fires. The chemical can be stored in extinguishers for long periods of time without replenishing. "MET-L-X" is an underwriters' Laboratories approved agent for combustible metal fires.

The Montana Department of Health and Environmental Sciences is in no way attempting to endorse or sell the product and throughout the handbook the term "sodium chloride based powder" is used to indicate that other such products may be equally efficient.

QUICK REFERENCE-GUIDELINES TO FOLLOW in the event of a fire involving pyrophoric metal.

(1) Never use water or moisture of any kind on fires involving sodium, potassium or lithium.

(2) Finely divided (i.e. filings and powder) pyrophoric metals are most hazardous, burn with intense heat and will usually react explosively with water.

(3) Avoid direct spray of water on hottest part of burning massive metal (see no. 1 above). Slowly work water spray inward from cooler fringe regions.

(4) Never use water on metallic fires in enclosed areas where the build-up of hydrogen gas may create an explosive hazard.

(5) If possible always try to control the spread of fire and let the metal burn itself out.

(6) Nearly all small metallic fires can be extinguished with sodium chloride based powders or dry magnesium oxide sand. Containers of one or both of these dry chemicals should be present wherever pyrophoric metals are used and/or stored.

(7) Combustible non-metal materials should not be stored near phrophoric metals.

(8) Respiratory protection (e.g. a self-contained breathing apparatus) should always be utilized by anyone attempting to combat a fire involving pyrophoric metals and/or radioactive material.

(9) The burning oxide from metallic fires normally presents a greater health hazard (airborne) than the heat or explosive properties.

(10) Smothering or confining metal fires is more desirable than spraying water on it and risking an explosion or dispersal of the burning metal.

QUICK REFERENCE-WHAT TO DO in the event of a Radiological Incident

(1) Perform life saving rescues and emergency first aid.

(2) Keep all persons as far away from accident scene as is practical.

(3) Avoid spreading contamination (i.e. liquid, solid or gas).

(4) Do not attempt to move or clean up any material involved with the incident.

(5) Stand upwind of fires.

(6) Obtain names of all persons involved with the incident.

(7) Detain all persons involved with the incident at the scene until the Radiological Emergency Response Team arrives.

(8) Eating, drinking and smoking in the area of the accident should be prohibited.

(9) Notify the Montana Department of Health and Environmental Sciences, Phone No. 449-3454

(10) Remain calm and wait for arrival of the Radiological Emergency Response Team.

PART I

EXAMPLES OF RADIOACTIVE AND METALLIC FIRE INCIDENTS to which you may eventually respond are listed below:

A. FIRE and/or EXPLOSION which occurs in an area where pyrophoric metal and/or radioactive materials are used or stored.

B. RESCUE procedures involving a victim of a pyrophoric metal and/or radioactive material fire or explosion.

/WHOM TO NOTIFY/ regarding a radiation emergency incident:

During business hours (8:30 a.m. to 5:00 p.m., Monday-Friday) call the Montana Department of Health and Environmental Sciences, Phone No.: 449-3454.

After hours, weekends, and holidays call the Montana State Civil Defense Agency, Phone No.: 449-3034. (Please refer to Appendices B & C for reporting procedures).

I. /WHAT TO DO/ if you arrive at the scene of a metallic or radioactive material fire:

A. Wear proper respiratory protection equipment (e.g. a self-contained breathing apparatus).

B. Incident involving a fire and/or explosion:*

1. Attempt to remove any injured persons up-wind and as far away from the burning material as practical (e.g. 200 feet). Administer emergency first aid if necessary. Additional information on handling a radiation contaminated patient is provided at the end of this handbook.

2. If possible, do not attempt to touch, clean up, or walk on any contaminated material that may be present.

*Note: The procedures listed here are by necessity general and may vary slightly depending on the chemical and/or physical nature of the material involved. Containing fires involving pyrophoric and/or radioactive metals will be covered in Part III of this handbook.

3. Look for any signs, labels or placards that may give you information regarding the chemical or physical nature of the material involved. Radioactive material is usually labeled with one or more of the identifying signs reproduced in Appendix A of this handbook.

4. Stay upwind of any burning material and avoid breathing any fire or explosion associated airborne materials.

5. Radiation exposure assessments may have to be made prior to proceeding into a radiation area. (Please refer to Appendix F for more information).*

6. Eating, drinking and smoking in the area of the incident SHOULD BE PROHIBITED to avoid internal body deposition of toxic or radioactive material.

7. An emergency response team from the Montana Department of Health and Environmental Sciences will respond to the incident, after being notified, as quickly as possible and will be able to provide needed technical assistance.

C. Rescue procedures which involve entering a radiation or metallic fire area:

1. Foremost consideration should be given to moving the victim out of the hazardous area. Even when life saving first aid is required, 5 or 10 seconds spent moving some distance away from the hazardous material may significantly contribute to reducing the exposure of victim and rescue personnel.

2. Potential personnel exposure to the radiation and/or toxic material must be considered and dose estimates should be made in order to approximate the length of time rescue personnel can remain in the exposure area.*

*Note: Radiation exposure estimates should be made by an individual adequately trained in radiation protection.

3. The possible need for respiratory protection, protective clothing, dosimetry and instrumentation must be considered (please refer to Appendix E for a list of recommended equipment and Appendix G for procedures to follow in maintaining and using survey and dosimetry equipment).

PART II

HANDLING A RADIATION ACCIDENT VICTIM

There are four (4) basic types of radiation exposure that you should know about:

1. Externally emitted radiation that penetrates body tissues.
   Examples: X-rays, gamma rays, beta particles and neutrons.

   Precautions to be observed while attending victim:

   The victim is not radioactive and poses no hazard to attending persons. Depending on the degree of exposure, the victim may become quite sick and show various symptoms including nausea and vomiting.

2. Radioactive material deposited on the skin and/or clothing. Examples: May emit alpha, beta, gamma or neutron radiation (or all four) and be in the form of a solid (e.g. powder), liquid or gas.

   Precautions to be observed while attending victim:

   Anyone touching the victim or handling his clothing may become contaminated. Unless life saving first aid is necessary, handling the victim should be avoided until a Radiation Emergency Response Team arrives. If touching or handling the victim is necessary the hands should be thoroughly scrubbed and washed with detergent and water following contact. If possible gloves (preferably made of impervious material) should be worn while handling the patient. Any additional parts of the body or clothing (e.g. shoes) that come in contact with the victim should receive similar decontamination.

It should be noted that contamination (particularly of the feet and hands) can spread amazingly fast. If transporting the contaminated victim in a vehicle becomes necessary for life saving purposes, the spreading of the contamination must be limited as much as possible (e.g. wrap the patient in a clean sheet or blanket). All persons and objects touched will need to be checked by the Radiation Emergency Response Team for contamination.

3. Radioactive material inhaled, ingested or internally deposited through a wound.
Examples: Alpha, beta, gamma and neutron (or all four) emitting substances in a solid, liquid or gaseous form may be involved.

Precautions to be observed while attending victim:

Normally, inhaled, ingested or wound deposited radioactive materials do not constitute a serious hazard to attending persons. The quantities consumed are normally low. Contamination problems may arise when vomiting, bleeding or excretion occurs and releases the radioactive material from the body. If this occurs the victim should be handled as if he were externally contaminated with a radioactive liquid.

4. Radioactive material in a solid form that is imbedded within body tissues.
Examples: Pieces of metal, glass or wood. This type of contamination usually follows an explosion and may involve particles that emit greater amounts of radiation than the previously mentioned forms of contamination. Gamma, beta, alpha and neutron radiation (or all four) are possible.

Precautions to be observed while attending victim:

This type of accident is the rarest of the four listed but could be the most hazardous to attending persons should it occur. If possible, contact with the victim should be avoided until the Radiation Emergency Response Team arrives.

PART III

PYROPHORIC METALS SUMMARY AND FIRE EXTINGUISHING RECOMMENDATIONS

A. Radioactive Pyrophoric Metals

Metal: Uranium (U)*

Properties: A naturally occurring radioactive element. May be found in isotopic forms including U-238 (the most abundant), U-235 and U-234 and U-233. These isotopes primarily emit alpha radiation with some gamma and beta. Primary hazards of uranium are internal body deposition and criticality which may occur with quantities of U-235 that exceed a total of 350 grams and U-233 that exceed a total of 200 grams or combinations of uranium in smaller individual quantities.** Finely divided uranium may ignite spontaneously at temperatures less than 300 degrees Centigrade (572 degrees F). Massive uranium (i.e. 1 kilogram or more) is difficult to ignite and normally does not constitute a pyrophoric hazard. Storage in an inert atmosphere such as helium is a satisfactory procedure.

Melting Point: Approximately 1130 degrees Centigrade or 2066 degrees Fahrenheit.

Fire Extinguishing Guidelines:

(1) Sodium chloride based powders (e.g. "MET-L-X") and dry magnesium oxide powder have been useful in combating uranium fires in industry.***

*Note: The chemical symbol of the element is given in parenthesis.

**Note: The weights given here are approximate and are termed the "critical mass" for a given isotope. This is the smallest mass of fissionable material that could support a self-sustaining chain reaction.

***Note: MET-L-X is a very fine sodium chloride powder with additives to increase its flow rate and is manufactured by the Ansul Chemical Company of Marinette, Wisconsin.

(2) Carbon dioxide, soda acid and foam fire extinguishers are not recommended.

(3) Total immersion of burning uranium (U-238, depleted or natural uranium only) in water is satisfactory only if the evolved hydrogen gas can be adequately dissipated.

Metal: Plutonium (Pu)

Properties: An artificially produced radioactive element. Several isotopes exist including Pu-238 and Pu-239. Both emit alpha radiation and some gamma radiation. Internal deposition (particularly in the lungs) can present serious health problems. Criticality danger may exist with quantities exceeding a total mass of 200 grams or combinations of plutonium in smaller individual quantities.* Finely divided plutonium turnings, filings and powders present a greater pyrophoric hazard than massive plutonium (i.e. 500 grams) and may spontaneously ignite in air. Burning plutonium reacts explosively with halogenated hydrocarbons.

Fire Extinguishing Guidelines:

(1) Magnesium oxide sand has been successfully utilized.

(2) Sodium chloride based powders have also been used.

(3) Helium, argon, or nitrogen gas applied to small fires in a gas "bonnette" apparatus has been shown to be effective.

(4) Lead powder, iron powder, copper powder, foam, plutonium dioxide and Halon 1301 gas** are not considered very effective.

(5) Applying water directly on burning plutonium metal is not recommended. Using water to control associated combustible fires (non-plutonium) is recommended.

Metal: Thorium (Th)

Properties: A naturally occurring radioactive element. A common isotope is thorium 232 which primarily emits alpha and gamma radiation. Thorium's pyrophoric properties are very similar to uranium with the exception that no criticality hazard exists.

Melting Point: Approximately 1845 degrees Centigrade or 3353 degrees Fahrenheit.

*Note: See footnote on page 5.
**Note: Halon 1301 gas is a trade name for bromotrifluormethane.

Fire Extinguishing Guidelines

(1) Sodium chloride powders, and magnesium oxide sand have been successfully used.

(2) Carbon dioxide, soda acid and foam fire extinguishers are not recommended.

B. Nonradioactive Pyrophoric Metals

Metal: Potassium (K)

Properties: Usually in the form of cubic, silver-metallic crystals. Reacts violently with moisture to form potassium hydroxide and hydrogen gas. Intense heat and explosive hazard exists during combustion. Spontaneously combustible in moist air or water. Strong alkaline properties of potassium metal combustion products make it very toxic both internally and externally.

Melting Point: Approximately 62 degrees Centigrade or 144 degrees Fahrenheit.

Fire Extinguishing Recommendations:

(1) The use of sodium chloride based powders on small pieces of burning potassium has been successful. These substances tend to "stick" to burning metal and smother the fire by sealing off oxygen.

(2) Do not, under any circumstances, apply water or any moist substance to a fire involving potassium.

(3) The application of sand is not recommended.

(4) Do not use ordinary fire extinguishers (i.e. carbon dioxide, soda acid, and foam).

Metal: Sodium (Na)

Properties: Light, soft, silver-white metal. Reacts exothermally with moisture. Exposure to body tissues or skin can cause severe thermal and chemical burns. Also reacts exothermally with the halogens, halogenated hydrocarbons and acids.*

Melting Point: Approximately 98 degrees Centigrade or 208 degrees Fahrenheit. Sodium-Potassium alloys are more pyrophoric and have lower melting points than the pure constituent metals.

Fire Extinguishing Recommendations:

(1) The use of sodium chloride based powders on small pieces of burning sodium has been successful.

(2) Do not use water, foam, soda acid or carbon dioxide fire extinguishers.

Metal: Lithium (Li)

Properties: Silvery light metal. Reacts violently with moisture, acids and oxidizers. Burning lithium emits toxic fumes of lithium oxide and hydroxide. Reaction with water produces hydrogen gas which is highly combustible and explosive in nature. Also reacts with nitrogen. Lithium combustion products are highly toxic.

Melting Point: Approximately 179 degrees Centigrade or 354 degrees Fahrenheit.

Fire Extinguishing Recommendations:

(1) The use of graphite based, magnesium oxide, or other dry powders recommended by processors of lithium have been used successfully on small fires.

(2) Sodium chloride based powders are generally not effective.

*Note: Halogens are flourine, chlorine, bromine, iodine and astatine and are normally in the diatomic form. Halogenated hydrocarbons are organic molecules that have chemically combined with one or more of the halogens.

Metal: Magnesium (Mg)

Properties: A dangerous fire hazard when in the form of dust or flakes. Difficult to ignite in solid form. Moisture increases the pyrophoricity. If water is applied there will be evolution of hydrogen gas during burning which will create an explosive hazard.

Melting Point: Approximately 651 degrees Centigrade or 1204 degrees Fahrenhiet.

Fire Extinguishing Guidelines:

(1) Smothering small pieces of burning metal with sodium chloride based powder has proven successful Care should be taken not to spread the burning metal.

(2) If possible, allowing the magnesium metal to burn itself out has also been shown to be effective.

(3) Magnesium oven fires may be controlled with boron trifluoride or boron tirchloride gas. The gas is toxic, however, and should not be used on fires in closed areas.

(4) Water should not be used directly on actively burning magnesium due to the explosive hazard involved. Careful application of water on "cool" fringes of the fire and on combustible material associated with the fire has been shown to be effective.

Metal: Aluminum (Al)

Properties: May be in the form of filings, powder, paste or solid. Finely divided aluminum is more hazardous than large solid pieces. Vaporizing liquids may react violently with the burning metal and should not be used. Explosion hazards exist whenever aluminum powder or dust is allowed to accummulate.

Melting Point: Approximately 660 degrees Centigrade or 1220 degrees Fahrenheit.

Fire Extinguishing Guidelines:

(1) Fires in aluminum pastes or slurries can usually be controlled with carbon dioxide followed by smothering with sand.

(2) Sodium chloride based powders applied to small aluminum fires have also been used successfully.

(3) Fires in dry aluminum filings or powder may be controlled by smothering in sand or other dry material recommended by the aluminum processor or supplier.

(4) Precautions should be taken to avoid spreading the burning metal.

(5) Aluminum powder, if burning by itself and not involving other combustible material, will form a crust which excludes oxygen and will eventually extinguish itself. Sand can be used to ring and isolate the fire.

Metal: Ziroconium and Hafnium (Zr & Hf)

Properties: Both metals are typically used as solid metal, crystals or a gray powder. Titanium-zirconium alloys are more pyrophoric and have a lower melting point than the pure constituent metals. Zirconium and hafnium are relatively stable under water at temperatures up to 50 degrees Centigrade. The dry powder form of these metals may combine explosively at elevated temperatures with oxygen, nitrogen, phosphorus, sulfur, halogens and other non-metals. Dry powders have a low ignition temperature and burn with an intensely hot flame which is difficult to extinguish.

If water and zirconium or hafnium are combined it should be at least 25% water by weight. Severe explosions have occurred when 5-10% by weight water was used to store these metals. The explosive hazard is primarily due to the evolution of hydrogen gas.

Melting Point: Zirconium-approximately 1830 degrees Centigrade or 3326 degrees Fahrenheit.
Hafnium-approximately 2227 degrees Centigrade or 4041 degrees Fahrenheit.

Fire Extinguishing Guidelines:

(1) Allow fire to burn itself out if possible.

(2) Smothering with dry sand or ground limestone may be effective.

(3) The use of sodium chloride based powders on small fires may also be effective.

(4) Normally water increases the burning rate and should not be used.

(5) Carbon dioxide, soda acid and foam fire extinguishers should not be used.

Metal: Titanium (Ti)

Properties: Normally found as a dark gray uncrystalized powder or as a white lustrious metal. Titanium will burn in atmospheres of carbon dioxide, nitrogen or air. Finely divided metal is the most hazardous and may spontaneously ignite. Highly explosive in the molton form when mixed with water.

Melting Point: Approximately 1800 degrees Centigrade or 3272 degrees Fahrenheit.

Fire Extinguishing Guidelines:

(1) Allowing the fire to burn itself out, if possible, may be the best extinguishing method.

(2) The use of sodium chloride based powders on small fires may also be effective.

(3) Argon and helium gases may be of benefit if applied in airtight enclosures.

Table I: A Guide to Extinguishing Materials Commonly Used or Not Used for Combating Metallic Fires

Metals	Extinguishing Agents For Non-Radioactive Metals						
	Magnesium Oxide Powder	Sodium Chloride Base Powder* (e.g. MET-L-X)	Carbon Dioxide	Water	Soda Acid	Foam	Explosive Hazard
Aluminum	unknown	yes	yes, slurries only.	yes, slurries only.	no	no	Moderate with water and aluminum dust.
Hafnium	unknown	yes	no	no	no	no	Moderate with water and aluminum dust.
Lithium	yes	no	no	no	no	no	Extreme with water and in closed area.
Magnesium	yes	yes	no	cool, non-burning massive metal only.	no	no	Extreme with water and in closed areas.
Potassium	unknown	yes	no	no	no	no	Extreme with water and in closed areas.
Sodium	unknown	yes	no	no	no	no	Extreme with water and in closed areas.
Titanium	unknown	yes	no	cool, non-burning massive metal only.	no	no	Moderate with water and in finely divided form.
Zirconium	unknown	yes	yes, for cool, massive metal only.	cool, non-burning massive metal only.	no	no	Moderate with water and in finely divided form.

APPENDIX A

RADIATION CAUTION SIGNS AND LABELS

Table 1 - A Guide to Extinguishing Materials Commonly Used or Not Used for Combating Metallic Fires-Continued

Metals	Extinguishing Agents For Radioactive Metals						
	Magnesium Oxide Powder	Sodium Chloride Base Powder* (e.g. MET-L-X)	Carbon Dioxide	Water	Soda Acid	Foam	Explosive Hazard
Radioactive Metals							
Plutonium	yes	yes	yes, for cool, massive metal only.	no	no	no	Moderate with water in closed areas.
Thorium	yes	yes	yes, for cool, massive metal only.	cool, non-burning massive metal only.	no	no	Moderate with water in closed areas.
Uranium	yes	yes, for cool, massive metal only.	cool, non-burning massive metal only.	no	no	no	Moderate with water in closed areas.

Note: The chemicals mentioned above are for small fires only. In general do not expect any chemical agent to extinguish large scope metal fires.

*Refer to the footnote at the bottom of page 5 .
**Beware of criticality problems with enriched (U-235) Uranium.

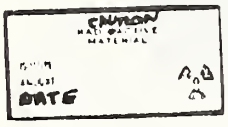
Key: Yes means the extinguishing substance has been shown to be effective.

No means the extinguishing substance has displayed certain undesirable or hazardous properties.

Unknown means that the extinguishing substance has not been used frequently enough to demonstrate either desirability or undesirability.

APPENDIX A

RADIATION CAUTION SIGNS AND LABELS



The color scheme on the radiation caution signs and labels above will normally be purple or violet symbols and lettering on a yellow background.

DEPARTMENT OF TRANSPORTATION (D.O.T) PLACARDING

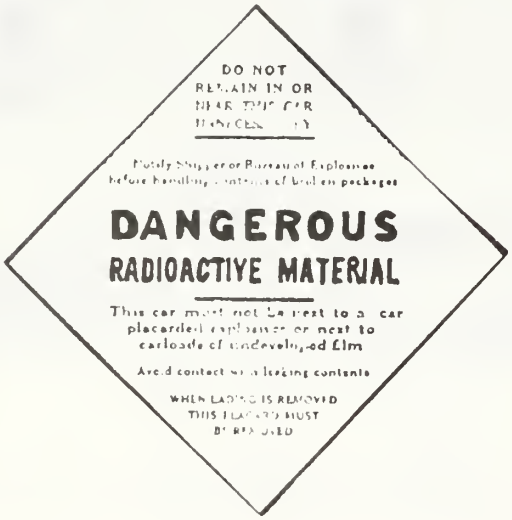
AND LABELING REQUIREMENTS

Highway vehicles used for transport of packages bearing Radioactive Yellow-III labels (see next page) must be placarded by the carrier, or by the shipper for sole use vehicles containing full loads of low specific activity materials. Placards printed with black letters four inches high and 5/8-inch width of stroke on a yellow background as shown above must be applied on the front, rear and on each side of the vehicle.

APPENDIX A

Department of Transportation (D.O.T.) PLACARDING AND LABELING REQUIREMENTS

CONTINUED



Unattended baggage or express railroad cars containing packages bearing Radioactive Yellow-III labels, and carload lots of low specific activity materials shipped via rail transport, must be placarded by the carrier. "Dangerous Radioactive Material" placards printed with red letters on white stock must be applied, one on each end and on each side. (49 CFR 174.393 (k), 174.541(b), 175.655(e) and 176.705).

APPENDIX A

Department of Transportation (D.O.T.) PLACARDING AND LABELING REQUIREMENTS

CONTINUED

"Radioactive White-I" Labels

Label must be white in color. The single vertical bar on the lower half of the label must be bright red in color. Labels must be applied on two opposite sides of each package having a dose rate not exceeding 0.5 millirem per hour at any point on the external surface of the package. Not authorized for Fissile Class II packages.

APPENDIX A

Department of Transportation (D.O.T.) PLACARDING AND LABELING REQUIREMENTS

CONTINUED

"Radioactive Yellow-II" Label

The upper half of the label must be bright yellow and the bottom half must be white. The two vertical bars on the lower half of the label must be bright red in color. Labels must be applied on two opposite sides of:

(1) Each package having a dose rate not exceeding 10 millirem per hour at any point on the external surface of the package and not exceeding 0.5 millirem per hour at 3 feet from the external surface of the package; or

(2) Each package for which the transport index does not exceed 0.5 at any time during transportation.

APPENDIX A

Department of Transportation (D.O.T) PLACARDING AND LABELING REQUIREMENTS

CONTINUED

"Radioactive Yellow-III" Label

The upper half of the label must be bright yellow and the bottom half must be white. The three vertical bars on the lower half of the label must be bright red in color. Labels must be applied on two opposite sides of:

(1) Each package having a surface dose rate exceeding 10 millirem per hour;

(2) Each Fissile Class III package.

APPENDIX B

RADIOLOGICAL INCIDENT REPORT FORMS

MONTANA DEPARTMENT OF HEALTH AND ENVIRONMENTAL SCIENCES
RADIOLOGICAL INCIDENT REPORT FORM

Hour _____ AM / PM Date _____

Name of person calling _____

Representing _____

Address _____

Telephone Number _____

Location of Incident:

City:

County:

Exact Location of Area Involved:

Radioactive Material Involved:

A. Chemical Name:

B. Chemical Form (e.g., liquid, solid or gas):

C. Amount of Activity (in Curies):

Description of Incident:

A. What Happened (briefly):

B. Time and Date of Incident:

APPENDIX C

ESSENTIAL INFORMATION TO PROVIDE

WHEN REPORTING A RADIATION INCIDENT

(Post this form beside a telepnone if possible)

ESSENTIAL INFORMATION TO PROVIDE WHEN REPORTING A RADIATION INCIDENT

1. Your name.
2. Representing
3. Address where incident occurred.
4. Exact location of area involved (e.g. storeroom, basement, etc.)
5. Radioactive material involved:
   a. Chemical name
   b. Chemical form (e.g. liquid, solid or gas)
   c. Amount of activity (in Curies)
6. Description of Incident:
   a. Tell briefly what happened.
   b. When did the incident occur (date and time).
   c. Persons injured (if any).
   d. Status of injured persons.
   e. Identify emergency response crew(s) that have arrived (e.g. fire dept., police, ambulance).

BASIC STEPS TO FOLLOW IN HANDLING A RADIOLOGICAL INCIDENT:

1. Keep all persons as far away from accident scene as is practical.
2. Perform life saving rescues and emergency first aid.
3. Avoid spreading contamination (i.e. liquid, solid or gas).
4. Do not attempt to move or clean up any material involved with the incident.
5. Stand upwind of fires.
6. Obtain names of all persons involved with incident.
7. Detain all persons involved with the incident at the scene until the Radiological Emergency Response Team arrives.
8. Eating, drinking or smoking in the area of the accident should be prohibited.
9. Remain calm and wait for arrival of the Radiological Response Team.

APPENDIX D

Procedures to Follow in Avoiding the Spread of Radioactive Contamination

(1) Know the chemical and physical form of the radioactive material you are dealing with.

(2) Rope or otherwise barricade the contamination area to avoid spreading radioactive and/or toxic material.

(3) If you are contaminated, shed outer clothing, including boots, prior to leaving the contamination area. Avoid spreading contamination outside the barrier or rope.

(4) Be aware of possible airborne contamination.

(5) Avoiding touching or stepping in contaminated areas if possible.

(6) Do not attempt to clean up a radioactive or toxic material contamination.

(7) Use soil or sand to "dam" liquids that are spilled and where run off is undesirable.

(8) Keep all equipment and clothing that you suspect to be contaminated inside the contamination barrier.

APPENDIX E: ESSENTIAL MATERIALS TO MAINTAIN RELATIVE TO A RADIATION INCIDENT

Obtaining and storing the items listed below will provide adequate supplies necessary for use in a radiation contamination incident.

ITEM	USE
G.M. Survey Meter	Surveys for contamination
Dosimeters & charger (preferably 0-200 mr range)	Personnel monitoring
Spare batteries	For use in G.M. survey meter
Plastic bags of all sizes	For disposing of contaminated materials
Plastic sheet	Covering ventilation ducts, if necessary, and covering contaminated areas.
Remote handling tongs or shovel	For handling contaminated objects
Radiation warning rope or ordinary rope, chord, etc.	For roping off and securing contaminated areas
Radiation caution signs and labels	For labeling contaminated areas and objects
Containers of various volumes	For collecting contaminated materials (i.e. liquids)
Masking tape	For sealing plastic bags and other containers, etc.
Soap and water	For decontamination
Cotton swabs	For decontamination
Absorbent materials	For decontamination
Waste containers (lined with removable plastic bags)	For radioactive waste disposal
Rubber gloves	For handling contaminated material
Shoe covers	For avoiding contamination of shoes
The fire department's own standard clothing, boots, gloves, and portable self-contained breathing apparatus	For avoiding personnel external and internal contamination

APPENDIX F

INFORMATION APPLICABLE TO UNDERSTANDING RADIATION QUANTITIES AND UNITS

I. Maximum permissible whole body exposure to X-ray, gamma ray or neutron radiation: 1.25 rem per quarter (3 months) or 5 rem per year.*

II. Recommended maximum "one time" exposure allowable in life saving emergency situations: 25 rem*

III. Minimum whole body X or gamma ray dose at which blood and blood forming organ changes can be detected: Approximately 50-100 rad.*

IV. Whole body dose (external X or gamma radiation) at which death may occur due to blood (i.e. bone marrow, liver and spleen) system damage: approximately 300 to 400 rad.*

V. Whole body dose (X or gamma radiation) at which approximately 50% of a randomly selected population would be expected to die within 30 days following exposure: approximately 400 to 500 rem.

Note: For simplification, the units rem, rad and R (roentgen), as used in this handbook, should be considered equivalent. Dose rates given are for occupationally exposed persons only.

APPENDIX F continued

Gamma ray emission rates and physical half life of selected nuclides expressed in roentgens per hour per curie at a distance of one (1) foot:

Radioactive Nuclide and its Chemical Symbol and Atomic Mass Number:	R/hr./Ci at 1 foot	Physical Half Life
Cesium 137 (Cs-137)	4.2	30 yrs.
Cobalt 60 (Co-60)	14.4	5.3 yrs.
Gold 198 (Au-198)	2.7	64.8 hrs.
Iodine 131 (I-131)	2.4	8 days
Iridium 192 (Ir-192)	5.9	74 days
Iron 59 (Fe-59)	7.3	45 days
Molybdenum 99 (Mo-99)	0.8	67 hrs.
Radium 226-(Ra-226)	9.0	1620 yrs.
Sodium 22 (Na-22)	12.4	2.6 yrs.
Technetium 99^{m} ($Tc-99^{m}$)	0.6	6 hrs.

APPENDIX G: CARE AND USE OF A GEIGER-MULLER (G.M.) SURVEY METER AND POCKET DOSIMETER

If possible each fire station should possess or have access to at least one (1) operable G.M. survey meter. This instrument is useful in detecting areas of gamma and/or beta radiation contamination. The instrument should only be used by a qualified individual who is responsible for keeping the instrument operable and calibrated.

The following procedures should be followed when using a G.M. survey meter to detect contamination:

(1) Be certain the instrument's batteries are good before using.*

(2) Be certain the instrument is properly calibrated before using.*

(3) Enclose the instrument and probe in a thin transparent plastic bag when surveying areas where airborne contamination is possible.

(4) Be certain that the beta shield is removed when surveying for beta radiation.

(5) Avoid touching the G.M. detector probe to contaminated material.

(6) Move the probe slowly over areas of suspected contamination.

(7) Keep a written record of all surveys and their locations.

(8) G.M. survey meters will not adequately detect alpha or neutron radiation. Low energy beta emitters (i.e. tritium and carbon 14) are not normally detectable unless a special thin window tube is utilized.

*Note: The establishment of a regular maintenance and calibration schedule is vital to the proper operation of the instrument.

APPENDIX G-Continued

The following procedures should be followed when using a pocket dosimeter and charger:

(1) Periodically (e.g. every 6 months) check batteries in the charger.

(2) If possible dosimeters should be charged to zero prior to use.

(3) If charging is not possible, be sure to note the dosimeter reading prior to entering the radiation area.

(4) It is recommended that the dosimeter's range be 0-200 mr.

GLOSSARY OF TERMS

Alpha Particle: A type of radiation consisting of a positively charged particle emitted by certain radioactive materials. The alpha particle is made up of two neutrons and two protons bound together which duplicates the constituents of the nucleus of a helium atom. It is the least penetrating of the three common types of radiation (alpha, beta, gamma) emitted by radioactive material, being stopped by a sheet of paper. It is not hazardous to man unless the alpha emitting substance has entered the body.

Beta Particle: A type of radiation emitted from the nucleus of atoms during radioactive decay. This particle has a single electrical charge and a mass equal to 1/1837 that of a proton. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron. Beta radiation may cause skin burns and beta-emitters may be harmful if they enter the body. Beta particles are easily stopped by a thin sheet of metal and normally give rise to some x-radiation.

Chain reaction: A reaction that stimulates its own repetition. In a fission (splitting) chain reaction a fissionable nucleus absorbs a neutron and fissions, releasing additional neutrons. These in turn can be absorbed by other fissionable nuclei releasing still more neutrons. A fission chain reaction is self-sustaining when the number of neutrons released in a given time equals or exceeds the number of neutrons lost by absorption in non-fissioning material or by escape from the system.

Criticality: The state of nuclear fissioning material when it is sustaining a chain reaction.

Dosimetry: The measurement of the amount of radiation delivered to a specific place or the amount of radiation that was absorbed there.

Exothermally: Being characterized by evolving or emitting heat or fire.

Fissile: A synonym for fissionable material.

Fissionable: The process of being split or divided. The nucleus of certain atoms are readily fissionable and may be used in nuclear physics to initiate a chain reaction.

Glossary of Terms Continued

Gamma Ray: High energy electromagnetic radiation that is emitted from the nucleus of various "excited" or unstable atoms. Heavy shielding is required to attenuate gamma rays.

Moderator: A material, such as ordinary water, heavy water or graphite, used to slow down high-velocity neutrons, thus increasing the likelihood of further fission.

Neutron: An uncharged elementary particle with a mass slightly greater than that of the proton, and found in the nucleus of every atom heavier than hydrogen.

Pyrophoric: A substance which can ignite spontaneously. Also used for substances which spark when struck.

X-Ray: A penetrating form of electromagnetic radiation emitted when electrons change energy levels or direction near an atom.

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